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Foreword

This report has been prepared by the National Industry Group (NIG) responsible for health and safety in general engineering. The report is one of a series dealing with a particular industry or sector of employment. The General Engineering NIG is one of a number of such groups which were set up to meet the need for an increasing specialisation in the Factory Inspectorate to match the increasingly specialist technology of industry itself. Each of the Factory Inspectorate's 21 Area Directors has, therefore, been made responsible for at least one major industry or sector of employment with one group of inspectors in that Area nominated as the National Industry Group.

The NIG's objectives include:

- providing a focal point for the collection of data about practices, precautions and standards together with a stimulus to the preparation of guidance, while pinpointing problems either specific to an industry or of a more general nature;
- developing contacts with bodies representing interests in a particular industry such as management, unions, suppliers or equipment and professional organisations;
- maintaining consistency of enforcement nationally in relation to an industry.

As the report shows, 'general engineering' is not a separate industry but a number of related industries, manufacturing a diverse range of articles but predominantly using engineering techniques. The report contains only a selection of matters which have received attention from the NIG since its inception in 1977 but it does illustrate the role of a NIG in identifying problems, assessing the need for technical standards and in developing practical guidance.

It is encouraging to note the successful development of a number of Joint Working Groups where the concept of self-regulation is engendered as both sides of industry come together in formulating practical guidance for their own particular section of industry. Where common problems in the field of health and safety within a section of industry have been identified, the NIG has approached representatives of employers organisations, relevant to trade unions and other bodies such as research associations and suggested a joint approach in drawing up reasonably practicable solutions which the industry can follow. The report contains brief details of how some industries have actively responded to this approach.

The safe guarding of power presses is a perennial problem. The Joint Standing Committee on Safety in the Use of Power Presses has continued its work of revising and updating standards on matters which can affect the safety of such machines. This report contains a review of the Joint Standing Committee's work and highlights the successful reduction in accidents at power presses brought about largely by implementing the standards recommended by the Joint Standing Committee over the years.

New manufacturing techniques are increasingly being introduced. The NIG has recognised the importance of developing standards for the safe operation of programmable control systems. Guidance has been prepared which will assist in ensuring the safeguards are incorporated at the design stage. It is generally recognised that while there are obvious safety advantages in a more automated manufacturing system there is need for constant vigilance that such advantages are not offset by the risks associated with any complex control system.

I hope that this report will be widely read and that it will assist in stimulating interest throughout the engineering industry towards active participation in improving standards of health and safety and in facing future problems in this vital section of the country's economy.

J D G HAMMER
HM Chief Inspector of Factories

Introduction

1 The term 'general engineering' covers a wide range of activities which might be seen as a number of separate and discrete industries. The manufacture of motor vehicles, aircraft, domestic electrical appliances, hand tools, railway locomotives or bicycles can all be considered separate industries as can most of the industrial classifications which are covered by the Engineering National Industry Group (NIG). They are, however, all engineering processes; they share the use of common techniques and they have, to a significant extent, common problems. A list of the industrial classifications covered by the Engineering NIG is given in the Appendix.

In order to deal with its wide spread of responsibility it has been necessary for the NIG to adopt a strategy which will, within the general framework of HSE policy, allow the development of uniform standards throughout the industry. This strategy is described below. It is important to stress, however, that the problems of the Engineering Industry are not merely the problems of engineering per se. The safety of machine tools, for instance, (important as it is) forms only a small part of the NIG's work; many other facets of health and safety are relevant as will appear in this report.

2 The NIG strategy entails initiatives in two principal directions:

(a) to encourage the creation by industry of Joint Working Groups (JWG) to consider health and safety problems in particular sectors of the industry and

(b) to seek the establishment of standards for specific activities which are common to the industry as a whole.

These initiatives overlap to some extent since any authoritative pronouncement by a JWG will obviously affect the thinking of other users of the same techniques. Thus the standards proposed by the JWG for the drop-forging industry will be relevant to the same processes carried out, say, in the Motor Vehicle Manufacturing Industry. As the pattern of JWGs expands it is thought that 'spin-off' of this sort will be of great value in ensuring that the same problems are not expensively solved several times in separate sectors of the Industry.

3 In its approaches to industry about the formation of JWGs the NIG has sought to emphasise the points:

(a) that the general duties placed upon employers by Sections 2 to 4 of the Health and Safety at Work etc Act 1974 (HSW Act) require, for their proper discharge, a positive assessment of hazards arising from the working environment and practices;

(b) that in a well-integrated trade or industry where the same working methods and practices are adopted there is a clear advantage in employers adopting a common approach;

(c) that by joint investigation of problems it may be possible jointly to establish reasonably practicable standards of precautions which will be acceptable to the enforcing authorities and can be uniformly applied;

(d) that HMFI will co-operate with industry in trying to arrive at agreed standards which can be applied throughout the industry and which can be accepted, in relation to the specific case, as providing compliance with the requirements of the Act;

(e) that in order to allow HMFI (as an operational arm of the Health and Safety Executive) to co-operate in this way the Committee or Group will need to be properly representative of both sides of the industry as well as the Inspectorate; and

(f) that in order that the proposals made by such a Group should be seen as authoritative the membership of it on both sides should be pitched at a level which would command respect in the industry both as to the adequacy of the proposals for the protection of the health and safety of employees and as to their commerical practicability.

4 In the preparation of guidance on specific health and safety issues common throughout the engineering industry as a whole, the NIG has relied upon the expert assistance of many people including specialist inspectors of the Midlands Field Consultant Group and HMFI Headquarters Specialist Sections; HSE's Research and Laboratory Services Division; the Employment Medical Advisory Service; outside bodies such as employers' associations; academic or research institutions and many individual firms. Some indication of the range of subjects which have been considered will appear from what follows, though it is not possible to deal fully with every single issue which has been investigated with a view to the preparation of guidance.

5 The most obvious example of concentration on a single issue of importance throughout the engineering industry is provided by the work of the Joint Standing Committee on Safety in the Use of Power Presses. The formation of the JSC long pre-dates the creation of the NIG but its work has continued unabated and in the period under review it has published revised guidance on a wide range of relevant issues. This is dealt with more fully elsewhere in this report.

6 Much of the work of the NIG is, of course, directed towards providing advice and guidance to inspectors in order to ensure some uniformity of approach to specific problems. Such advice is often tentative, but as experience grows it will become available to industry either through the medium of publications of Joint Working Groups or similar bodies or by direct publication by HSE. Instances of this will appear in this Report and it may be expected that the flow of information will increase as time goes on.

Drop forging

7 Drop forging is a traditional industry in which general working methods have altered relatively little over the years. The work is for the most part physically demanding and is typically carried on in elderly buildings which do not lend themselves easily to modern improvements. Although drop forges are found in many parts of the country the industry is centred in the West Midlands and particularly in the old and crowded parts of the black country. It is not to be supposed, however, that the industry is not vigorous and forward-looking. As long ago as 1958 a committee of the industry recommended that there should be consultations between employers, workers and HM Inspectors of Factories to consider matters relating to the safety, health and welfare of persons employed in the industry and this resulted in the creation, in 1964, of a Joint Standing Committee on Health, Safety and Welfare in the Drop Forging Industry.

8 The JSC reported in 1966 and its proposals provided a reliable guide to good practice in the industry. It was not, however, universally followed and it was to some extent overtaken both by technological changes and by changes in attitude to industrial risk. It is to be noted, for instance, that the 1966 Report made virtually no mention of noise as being a problem and it skated lightly over the difficult problem of atmospheric contamination from die lubrication. With the demise of the JSC it seemed appropriate to consider a new initiative and after discussions with the National Association of Drop Forgers and Stampers (NADFS) they agreed to set up a Joint Working Group. The Group first met in May 1979 and work has continued in spite of a trade recession which has badly affected the industry.

9 The Group is composed of six nominees of the NADFS, four nominees of the Confederation of Shipbuilding and Engineering Unions and one nominee of HM Factory Inspectorate. The HMFI representative is a Principal Inspector in charge of the Industry Group in the West Midlands Area which has major responsibilities in relation to the drop forging industry. He is able to request, as necessary, the assistance of specialist Inspectors from the Midlands Field Consultant Group (FCG), and doctors from the Employment Medical Advisory Service (EMAS). The NADFS provides the secretariat of the Group.

10 The JWG has set up several sub-committees to study specific problems and two major problems, those of noise and atmospheric pollution, have received early attention. The noise problem has been divided into two parts: hearing protection and noise reduction. It is recognised that the problems of reducing forging noise at source to an acceptable level are, because of the nature of the process, intractable. The JWG has therefore concerned itself with proposals for the protection of the person. In other parts of the drop forging factory the problem is less difficult to overcome and the JWG has been engaged in preparing proposals for the reduction of noise at source. The JWG has produced a report on personal hearing protection *Noise Hazards in the Drop Forging Industry. Part 1 – Personal Protection,* obtainable from the National Association of Drop Forgers and Stampers, 245 Grove Lane, Handsworth, Birmingham B20 2HB and a further report on the control of noise in ancillary processes is in preparation.

11 On the problems of atmospheric pollution the JWG has prompted an investigation into the problems of die lubrication. It is essential that the hot forging can be readily released from the die and it has been common for oil, graphite or sawdust to be used for this purpose. This necessarily results in the release into the general atmosphere of considerable quantities of smoke and fume which it is difficult to control in the circumstances in which the work is done (Fig 1, Fig 2). The use of water-based lubricants appears, subjectively, to improve working conditions immensely and many such lubricants are now being marketed. The NIG is looking carefully at the available lubricants with a view to encouraging their wider use. However, it is seeking reassurance that water-based lubricants are efficient in use and also that their chemical composition will not introduce any undesirable contaminant into the atmosphere.

12 It is expected that the reports now in preparation on noise and personal protection will, in due course, be followed by others dealing with subjects such as safe methods of die changing, welfare facilities etc. In addition to this work members of the JWG have assisted HMFI in promoting new attitudes to health and safety in drop forging. They have assisted the HSE in the production of a film, entitled 'Damaged, Not Daft' which shows reconstructions of accidents which have occurred in drop forges as well as highlighting the medical and social consequences of noise induced hearing loss. (Available from the Central Film Library, Chalfont Grove, Gerrards Cross, Bucks SL9 8TN.) Representatives of the industry participated in a training conference which was attended by inspectors with a special interest in drop forging. The principal speakers included representatives of the General and Municipal Workers' Union, the National Association of Drop Forgers and Stampers and the Drop Forging Research Association. It was evident at the conference that the interchange of ideas was mutually beneficial and one of the immediate results was the preparation by the NIG of a training package for inspectors which it is hoped will ensure a full appreciation of the special problems of the industry.

Industrial fasteners

13 After prior discussions with the British Industrial Fasteners Federation (BIFF) a Joint Working Group on health and safety was formed in May 1979. It is composed of 4 nominees of the Federation, 2 from the appropriate trade unions (The Screw, Nut and Bolt and Rivet Trade Union and The Transport and General Workers Union), 1 from the West Midlands Engineering Employers' Association and 1 from the Health and Safety Executive. The HSE representative is one of HM Principal Inspectors of Factories.

14 The industrial fasteners industry, like drop forging, is a traditional Midlands-based industry with health and safety problems which arise mainly from the nature of the process itself. The members of BIFF have recognised the need to look again at their working methods, procedures, plant and environment in order to identify and investigate any health and safety problems and to seek solutions to them. Four sub-committees have been set up to deal with

(a) statistics;
(b) noise and fume;
(c) training and eye protection; and
(d) systems of work and machine safety

These conditions have continued to work vigorously in spite of the worsening conditions of trade. An interim report providing guidance to the industry on Noise, Oil Mist and Transmission Machinery was published in May 1982 and is available from the British Industrial Fasteners Federation, Queens House, Coventry, West Midlands. A final report, which is in the course of preparation will deal with guarding of the tool area of cold heading machines.

Spring manufacture

15 A Joint Working Group on health and safety in the Spring Industry was created in October 1980. Its first format is very similar to the other JWGs but it is notable for the fact that the first approaches about its formation were made by the Spring Research and Manufacturers' Association (SRAMA) rather than HSE. The Group compises 6 nominees of SRAMA, 2 nominees of the Confederation of Shipbuilding and Engineering Unions (CSEU) and HM Senior Principal Inspector of Factories responsible for the Wire Industry representing HSE.

16 The JWG has set up five working parties to deal with various aspects of health and safety. These are:

(a) accident statistics;
(b) safeguarding of machinery;
(c) systems of work;
(d) health and environment; and
(e) publicity and safety promotion.

The hardmetal industry

17 (a) Hardmetal consists of tungsten carbide with various additions, mainly of cobalt but with some titanium, tantalum, vanadium and niobium. It is

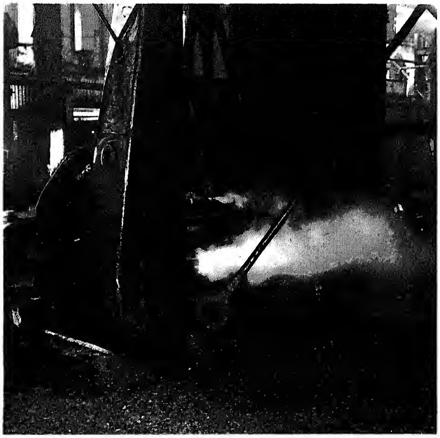

Fig 1 Oil fume emitted during lubrication of the dies of a drop hammer

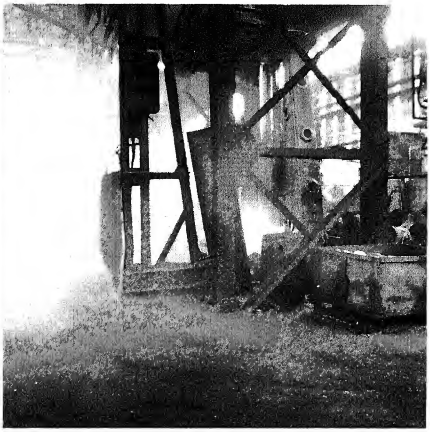

Fig 2 Fume in the general atmosphere of a forge

used as a cutting edge on some tools, drills, broaches and in dies, tyre studs and ball point pens.

(b) Health risks may arise from the dust evolved during the manufacture of hardmetal and in the machining of hardmetal articles.

(c) The Engineering NIG has recently joined with the British Hardmetal Association and members from the Amalgamated Union of Engineering Workers and the Transport and General Workers Union to form a Joint Working Group to consider the health of workers in the hardmetal industry.

(d) The Joint Working Group aims to:

(i) identify problems in the industry's working methods, procedures, plant or environment which might be prejudicial to the health of persons employed,

(ii) investigate such problems with a view to establishing whether or not action is required to minimise risks,

(iii) propose solutions to problems which give rise to a risk to health,

(iv) to consider what measures might be necessary in relation to new processes provided for use in the industry so as to ensure that they are without risk to health,

(v) consider what information, instruction, training or supervision is needed to ensure health at work in the industry,

(vi) publish for the benefit of employers and employees in the industry the results and conclusions formed during the preceding considerations.

Radiator repairers

18 After initial explanatory meetings with individual groups a Joint Working Group was established in 1982 with the aim of investigating health and safety problems within the industry and improving working conditions. The industry is represented on the Joint Working Group by the Federation of Radiator Repairers and Remanufacturers, the National Association of Radiator Repairers, and Inrad. Employees are represented by the Amalgamated Union of Engineering Workers and HSE is represented by one of HM Principal Inspectors of Factories.

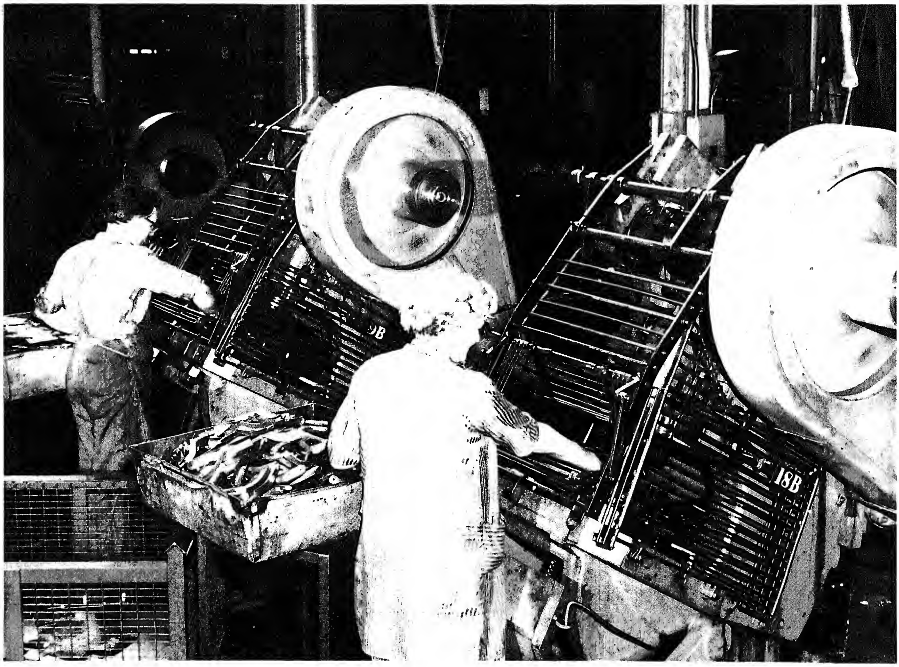

Fig 3 Fixed interlocked guarding on 50 ton power presses

19 The main problem identified by the JWG has been the hazard of inhalation of lead fumes by employees engaged in the stripping down and rebuilding of radiators. Information on exposure levels and control techniques has already been made available to employers and the work is continuing.

Other joint activities

Joint Standing Committee on Safety in the Use of Power Presses

20 The Joint Standing Committee (JSC) was appointed in 1946 following a recommendation in the report of a committee appointed by HM Chief Inspector of Factories in 1940 to examine the problems of power press safety. Between 1950 and 1970 the JSC produced eight reports on various aspects of press safety. In 1976 it was decided that the information then available should be up-dated and incorporated into a single document; this work has proceeded. The revised standards are being published in groups as they are prepared but in a common format so that they can, when complete, be bound together in a suitable ring binder. The first of these reports containing six sections dealing with General Matters, Electrical Equipment, Arrestor Brakes, Clutches and Brakes, Guarding Systems, and Safety in Toolsetting and Try-out was published in 1979. This was followed in 1981 by the publication of a further section on Press Tool Design — Safety in Manipulation. Further sections on Press Brakes and Material Feeding and Component Ejection Systems are in preparation.

21 Since the Second World War the JSC has made a significant contribution to the prevention of accidents at the tools of power presses. During the war such accidents were running at over 1000 per year; in 1979 there were 48 reportable accidents. There are many factors which may have influenced this notable improvement such as, for instance, the varying level of industrial activity or the introduction of automatic feed and delivery devices, but there can be no doubt that the major factor in reducing accidents has been the improved standards of safeguarding and maintenance which has resulted directly or indirectly from the work of the JSC. The increased use of the interlocked guard (Fig 3) was probably one of the most potent factors in reducing press accidents but the 1945 Report did propose, among other things, that it should be made a statutory requirement that presses and guards should be thoroughly examined at regular intervals and be tested daily. Regulations incorporating these proposals were not in fact made until 1965 but the effect of their introduction appears from the statistics to have been immediate and dramatic (Fig 4). This beneficial legislation was strengthened in 1971 by the Power Presses Amendment Regulations which made it mandatory for copies of examination reports which revealed major defects to be sent to the Factory Inspectorate. This in turn was followed by the introduction of the Health and Safety at Work etc Act 1974 and, subsequently, by the Safety Representatives and Safety Committees Regulations 1977. How far these various factors have influenced the incidence of accidents it would be difficult to assess but there can be no doubt that the foresight of the 1940 Power Press Committee and the patient work of its successor, the Joint Standing Committee have had a remarkable effect on what was considered (and in many countries still is considered) an intractable problem.

Power Presses Examination Panel

22 The Panel is an informal body which was created in 1969 to provide a forum for representatives of those inspecting organisations which provide ‘competent persons’ to carry out the thorough examination and tests of power presses and their safety devices as required by the Power Presses Regulations 1982. The Engineering NIG provides the chairman and secretary of the Panel and meetings are attended by specialist inspectors of the Midlands Field Consultant Group.

23 Membership of the Panel is not restricted and most of the firms or bodies which provide plant inspection services send representatives to the meetings. These include insurance companies, press manufacturers, safety device manufacturers and a number of independent companies offering inspection services. The discussions generally centre around technical issues arising from the inspection procedures and these have included the use of stroke adjustment locking plates, blockage of exhaust silencers and clutch and brake failures. The exchange of information and experience between the various inspecting organisations, and between them and the Factory Inspectorate, is of great value in ensuring a uniform approach to power press safety. Such a forum also provides an opportunity for the exchange of information on current legal requirements and has given an opportunity for the Panel to influence the form of the reporting procedures required by the Regulations.

Motor Industry Safety Group

24 The Motor Industry Safety Group provides a forum in which senior safety officers of the principal firms in the motor vehicle industry exchange views and information. Through its Machine Safety Sub-Committee it also takes the initiative in proposing safety standards. The NIG and Midlands FCG are both represented on these committees. During this period the Group, with the assistance of the Machine Tool Industry Research Association (MTIRA), has produced guidance on the safeguarding and the installation, commissioning and acceptance, of transfer machines and other special-purpose machine tools (Fig 5). This guidance has been published by the Machine Tool Trades Association as two separate booklets*.

The rapid development of industrial robots and their applications within British Industry has led to concern for the safety of personnel involved in their programming, operation and maintenance. Following requests from industry, MTIRA set up a working group in 1980 to discuss the safety implications of robot use. The NIG has contributed to the work of this group and a document covering the basic principles of safeguarding robots has been published†.

Liaison on publications with industrial organisations

25 In addition to the established and continuing liaison with different sectors of the industry the NIG has been involved with Employers' Associations in the preparation of guidance on specific aspects of health and safety in particular processes. Thus the NIG has provided advice to committees of the British Scrap Federation on safety in the use of fragmentisers* (Fig 6) and to the British Independent Steel Producers

* *Code of Practice – Safeguarding of Transfer Machines and other Special Purpose Machine Tools.*

Code of Practice – Safeguarding of Transfer Machines and other Special Purpose Machine Tools – Part 2 – Installation, Commissioning and Acceptance.

‡ *Safeguarding of Industrial Robots Part 1 – Basic Principles,* Published by Machine Tool Trades Association, 62 Bayswater Road, London W2 3PH.

* *Safety Guide – Prevention of Explosions in Fragmentisers* published by British Scrap Federation, 16 High Street, Brampton, Huntingdon, Cambs PE18 8TU

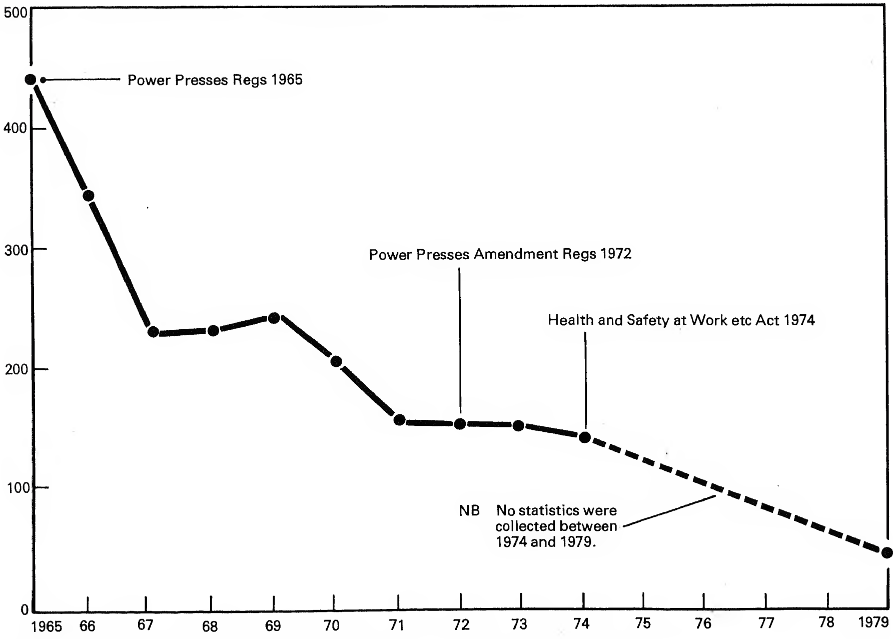

Fig 4 Power press accidents 1965-1979 Accidents at the tools of mechanical presses and press brakes

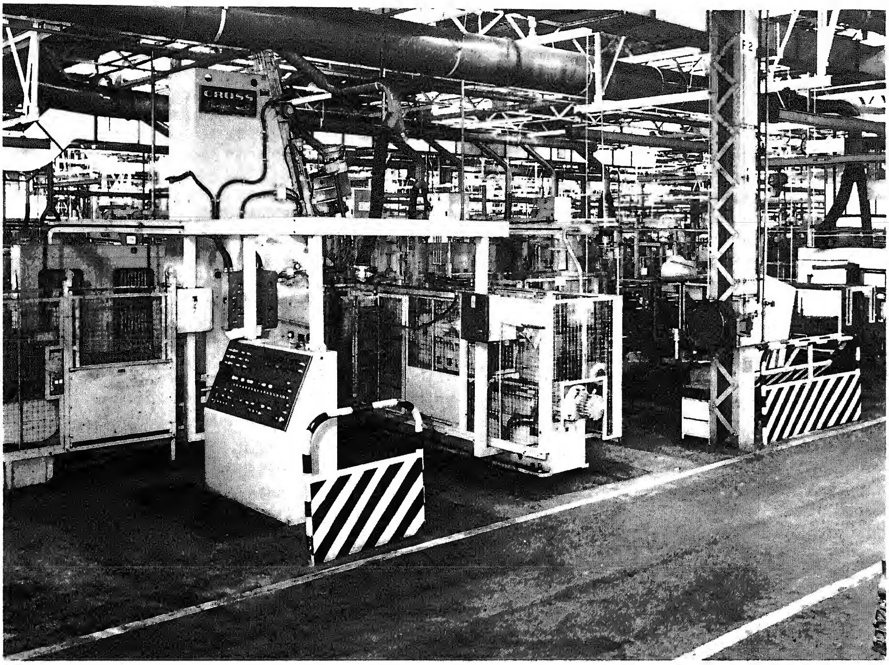

Fig 5 Transfer machine with fixed and interlocked contour guarding

Association on the safeguarding of strip-slitting lines* to the National Association of Steel Stockholders on safety in steel-stockholding and related processes†; and to the Cold Rolled Sections Association on the safe working of cold roll-forming lines‡. Similar liaison has been maintained with many other organisations who produce, or propose to produce, guidance on health and safety in engineering factories. These have included the Machine Tool Industry Research Association, the British Hard Metals Association, the Contract Heat Treatment Association and the Wolfson Institute of Aston University.

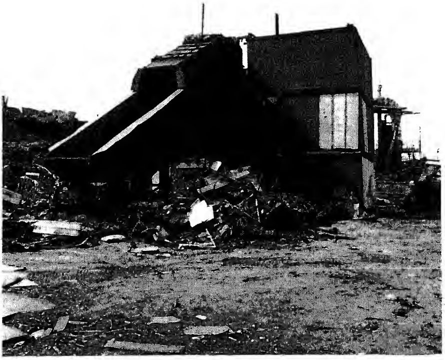

Fig 6 Scrap metal fragmentising machine

* *Guidelines to the Safe Operation and Guarding of Strip Splitting Lines* published by British Independent Steel Producers Association, 5 Cromwell Road, London SW7 2HX

† *Guidelines on Safety in Steel Stockholding and Related Processes* published by the National Association of Steel Stockholders, Lennig House, Masons Avenue, Croydon CR9 3NU

‡ *Code of Practice for the Safe Working of Cold Roll-Forming Lines* published by the Cold Rolled Sections Association, City Centre Tower, 7 Hill Street, Birmingham B5 4UU

Specific issues

26 The NIG has been concerned with a very wide range of specific issues in pursuance of its co-ordinating function in relation to health and safety in the engineering industry. Most of the advice which results from is enquiries is directed to those Factory Inspectors who work in the relevant Industry Groups in order to try to ensure a uniform approach to important problems. This sort of work arises in two ways; either it is planned as part of the NIG's programme or it is taken up as a result of Inspectors identifying problems in engineering factories throughout the country. Many such cases are referred to the NIG to seek possible solutions and as part of Factory Inspectors' search for uniformity of approach in applying the law on technical matters. Some of the 'reactive' issues do, of course, become part of the planned programme when their investigation needs extensive and time-consuming enquiries. The following paragraphs give a few examples from the large number of issues with which the NIG has been invovled. They are chosen as illustrative of the fact that the Engineering NIG is not wholly concerned with problems of mechanical engineering per se. The technical and scientific investigations and reports upon which the NIG's advice is based are prepared by the Midlands Field Consultant Group or by the Specialist Sections at HMFI headquarters.

Bacterial contamination of cutting oils

27 Most soluble cutting oils which contain water will support the growth of a wide range of micro-organisms, some of which may be potential pathogens. Initial contamination of the cutting lubricant may occur in many ways (e.g. airborne dusts, infectious water used for dilution) and once present in the tank may grow to the full potential of the nutrients present and eventually the oil may cease to be effective, scum and slime may appear and a foul odour may be produced. Microbial populations may, however, be considerable long before the obvious signs of oil deterioration appear.

28 There is evidence to suggest that contaminated cutting oils may present a health hazard to employed persons from the effects on the skin through cuts and abrasions. In some circumstances, where cutting oils may be liberated into the air as fine droplets, there may also be a risk of respiratory effects — particularly to persons suffering from bronchitis or asthma. It is highly desirable, therefore, that measures should be taken to prevent microbial growth in the oil. The usual way of seeking to do this is to add certain biocides to the oil but it is not thought that this precaution, by itself, is likely to be effective over any prolonged period.

29 Although the use of biocides at correct dosages will assist it is thought that for effective control of microbial growth adequate monitoring is essential. The level of infection in the oil can be conveniently measured by using dip-slides which are pre-coated with sterile growth media which will allow microbial colonies to develop on the coating in such a way as to allow their numbers and appearance to be compared with a calibration chart. Such dip-slides are commercially available. All parts of the oil supply system, including the concentrate and the water used for dilution may be monitored by the user in this way. Control measures to reduce the risk of contamination will vary according to the way the oils are used but the following basic precautions are among those which should be considered:

(a) oil concentrates should be obtained in the smallest practicable size of drum. They should be kept clean and cool and not tapped until required;

(b) oil should be diluted with the correct amount of fresh water at the last practicable moment in a series of small tanks, rather than in one large one;

(c) tanks should be sealed and filters should be fitted to air displacement lines;

(d) made up coolants should not be retained for topping up;

(e) tanks, pipe lines and taps, should be cleaned and steralised with steam or by other heating methods before a new change of oil is used;

(f) no unwanted oil should be allowed to stand in containers;

(g) contamination of the oil by waste and litter should be avoided;

(h) machines should be kept clean and wiped down thoroughly at the end of each shift.

Vehicle finishing units – fire and explosion hazards

30 Vehicle finishing units are widely used for spray-painting cars and commercial vehicles, and for drying and/or curing the applied paint. The units comprise one or more ventilated enclosures which are used for spraying and then the subsequent drying or baking of the applied paint. Fire and explosion hazards can arise from the fuel used to heat the units, from the solvents used in the paints or from the petrol in the tank of the vehicle being sprayed.

31 Because developments in the technique were making existing information out of date and were resulting in varying standards of safeguards being adopted, it was recognised that new and authoratitive guidance was necessary and the assistance of specialist inspectors from HMFI headquarters was sought. The investigations involved close co-operation between the Engineering NIG and HM Chemical Inspector of Factories from the HQ Section which deals with fire and explosion hazards. There was, in addition,

consultation with representatives of the major suppliers, manufacturers and importers of vehicle finishing units. This has resulted in the publication of comprehensive up-to-date advice*.

Electrical testing

32 During 1978 a programme of planned special visits was arranged to factories where electrical testing was carried on as part of the production process. The premises to be visited were identified by the Standard Industrial Classifications (SIC) and included those undertaking the manufacture of broadcast receiving and sound-producing equipment (SIC 365/2), of domestic electrical appliances (SIC 368), of electrical lamps (SIC 369/4) and of electric light fittings, wiring accessories etc (SIC 369/5). 302 returns were made by the visiting inspectors and it is disappointing to report that production-line testing with exposed electrically-live parts was found to be common practice when safer methods could have been employed. A cautionary booklet describing good practice* has been available for many years.

33 The range of precautions available for production-line testing includes:

(a) tunnels or other automatic testing equipment with a high degree of safeguarding from contacts with live connections;

(b) interlocked enclosures using suitable limit switches properly installed and connected;

(c) special purpose testing jigs;

(d) earth free areas;

(e) test supplies not referenced to earth (use of isolating transformers);

(f) application of sensitive earth leakage detection devices;

(g) low voltage supplies for continuity testing;

(h) protection of all unnecessarily exposed terminals;

(j) use of special purpose adequately protected connectors;

(k) use of proprietary plugs, sockets and temporary connectors;

(l) use of DC supplies instead of AC where practicable;

(m) permanent installation of test indicators, instruments etc;

(n) testing staff under immediate supervision and not alone;

(o) selection and training of testing staff to ensure that they have sufficient technical knowledge and experience to avoid dangers;

(p) test areas set apart and the use of staff with high levels of knowledge and skill where more complex testing techniques are necessary;

(q) emergency disconnection facilities;

(t) test equipment having a limited current capability to prevent a dangerous electric shock, and

(s) automatic disconnection of test supply at low current levels (e.g. 5 mA)

Not all of these precautions are likely to be appropriate to any particular testing situation but it is clearly necessary that a positive assessment of risk must be made and the appropriate precautions adopted if the risk of injury from electric shock is to be avoided. For this reason it would seem desirable that sectors of the industry with common problems should seek common solutions which can form the basis for a code of practice. Such an approach has already been adopted by the Radio, Electrical and Television Retailers' Association (RETRA) which has, after consultation with HM Factory Inspectorate, published recommendations for electrical safety in television, radio, and audio equipment testing and servicing‡. A similar publication has also been prepared by the Electrical Electronics Telecommunications and Plumbing Union (EETPU) in consultation with HM Factory Inspectorate and members of the National Television Rental Association Ltd§.

Motor vehicle repairs – fire and explosion hazards

34 The necessary presence of highly flammable liquids in workshops where motor vehicles are serviced or repaired introduces an important hazard which is not always appreciated by those who work in them. 373 injuries from this cause were reported to HMFI in the period 1970-80 and 12 of these were fatal. It will be seen from Table 1 that the ignition of petrol vapour was the principal cause of the incidents reported and the sources of ignition in Table 2 suggest that the presence of flammable material and vapours was not properly considered by those undertaking the work. A fire and explosion may cause injury to more than one person; it may, on the other hand cause damage to property without injuring anyone. Of the 372 reported incidents, 34 caused no injury to persons, but the remaining 338 incidents produced the 373 injuries mentioned above.

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* Guidance Note PM 25, *Vehicle finishing unit: fire and explosion precautions*, available from HMSO.

† Health and Safety Series Booklet HS(G)13: *Electrical Testing*, HMSO

‡ *Recommendations for Electrical Safety in Television, Radio and Audio Equipment Testing and Servicing* obtainable from The Radio Electrical and Television Retailers' Association Ltd, RETRA House, 57-61 Newington Causeway, London SE1 6BZ.

§ *Safety Health – Welfare Code of Practice: Television and Audio Servicing Industry* obtainable from EETPU, Hayes Court, West Common Road, Bromley BR2 7RU.

Reported incidents arising from the ignition of flammable materials in motor vehicle servicing and repair shops 1970-80

	Incidents
Petrol	320
Oil/Diesel	9
Plastic/Rubber/Glass Fibre/Underseal/etc	9
Paraffin	7
Paint/Thinners	3
Exhaust gases	3
Brake fluid	2
Electrical wiring	1
Grease	1
Oxyacetylene, etc	1
Acetone	1
Methylated spirit	1
Other hydrocarbons	2
Not specified	12
Total	**372**

Table 1 Materials

	Totals
Welding torch	114
Vehicle electrics	85
Low voltage hand lamp	38
Background heating	21
Mains hand lamp	23
Matches/Cigarette lighters	15
Cigarettes	8
Nearby electrical apparatus	9
Friction spark	5
Static	4
Gas burners	2
Exhaust pipe	2
Lit rag	2
Blow lamp	3
Fixed lighting	1
Wiring	1
Paraffin lamp	1
Not known	38
Total	**372**

Table 2 Sources of ignition

35 Although in most of the cases reported the risk of fire was evident (even if disregarded) there were some cases where the possibility of ignition of the flammable material was not readily foreseeable. Accidents have been reported which were caused by the rupture of a plastic fuel line and the subsequent ignition of petrol vapour while hot work was being done on the vehicle. In no case was the work connected with the fuel system and it seems likely that the application of heat to metal components near the path of the fuel line (e.g. to release and remove an exhaust pipe or to weld the chassis) may so soften the plastic fuel line as to cause a petrol leak.

36 The prevention of petrol leaks caused by the softening of plastic fuel lines presents some difficulties because

(a) the path of the fuel line may be difficult to trace either because it is covered by underseal or because it runs inside a box section; and

(b) it is difficult to assess the amount of heat transfer. Direct impingement of the flame upon the fuel line is not necessary to create the conditions for rupture of a plastic pipe.

37 In order to minimise the risk of fire from this cause, the following precautions should be adopted:

(a) Where extensive hot work involving welding on the underside of motor vehicles is to be carried out, the petrol tanks and fuel supply pipe should be removed. Where it is necessary to drain the petrol tank, this should never be carried out whilst the vehicle is standing over a pit. The fuel should be carefully drained into a container of adequate size, which should be closed and removed to a safe place. There should be no sources of ignition within 2m of the vehicle whilst the tank is being drained.

(b) One means of removing petrol from the fuel tank is by the use of a mobile fuel retriever (Fig 7). This is considered an improvement on the general practice of draining petrol into a container when the vehicle is standing on a ramp. Fuel retrievers consist of small mobile tanks fitted with pumps and suction hoses which, when inserted into a vehicle fuel tank, allow the petrol to be quickly pumped out. The system is enclosed and the petrol can be retained until work on the vehicle is finished and the petrol tank replaced. Several different types of fuel retriever are available and care should be taken to ensure that the type used is suitable for use with low flash point materials. Fuel retrievers cannot be used on vehicles fitted with anti-siphon devices.

(c) Where hot work is being done on a small scale, e.g. the freeing of rusty exhaust pipes, it may not be reasonably practicable to remove the tanks and so the following precautions should be considered:

(i) the course of the petrol pipe should be identified. This may be difficult where the pipe runs inside a box section or is concealed by structural members or by layers of undersealing compound;

(ii) the fuel line should be shielded with fire resisting material which will protect the pipe from flame impingement, although this will offer no protection from conducted heat;

(iii) it is generally safer to retain petrol in it to ensure a petrol vapour concentration above the upper flammable limit. The task should be shielded

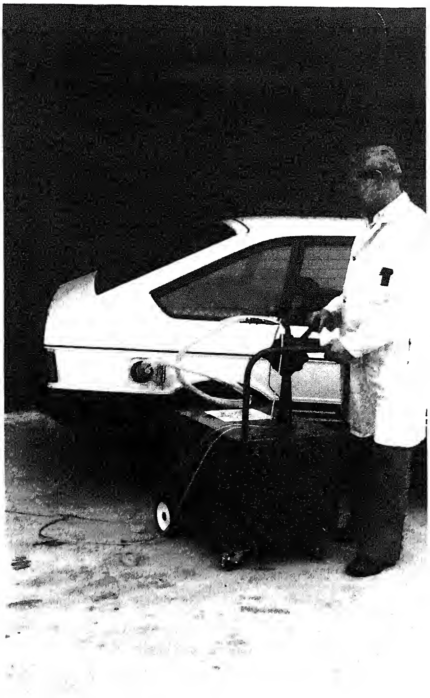

Fig 7 Mobile fuel retriever

against the risk of accidental flame impingement although the shielding will not protect against conducted heat;

(iv) if the vehicle is fitted with a tap on the tank outlet, it should be closed while work is in progress.

38 Another fire hazard which may not be obvious arises when welding or flame cutting is done on car bodies which have cavities filled, for insulation purposes, with cellular plastic — usually polyurethane foam.

39 Polyurethane foam burns very rapidly when it is ignited and generates very large quantities of smoke. The smoke itself has an unusually high temperature and contains not only carbon monoxide (which is produced in most fires) but also hydrogen cyanide and isocyanates. It is desirable, therefore, that persons who may apply heat to car bodies which contain this material should be aware of the risk and take suitable precautions.

40 Before flame cutting or welding insulated parts of a vehicle, as much of the foam as possible should be scraped away and removed. When this cannot be done as, for example, when the foam is enclosed in a box section, fresh air respirators should be worn by operators. In these circumstances a hole should be drilled in the section before flame cutting is commenced, to allow the products of heating the foam to escape. This hole should be placed so as to direct the gases away from the operator. In addition to the general fire precautions available in the premises concerned, at least one 9 litre water extinguisher or a hose reel should be kept immediately available for use at all times when hot work on insulated body parts is undertaken.

Use of 1,1,1 - Trichloroethane as a degreasing agent

41 1,1,1 — trichloroethane is widely used in the engineering industry as a cold cleaning or degreasing solvent. It is sold (usually with small additions of stabalisers and corrosion inhibitors) under a number of different trade names and is commonly advertised as a 'safer' solvent. This description is presumably based principally on the fact that its Threshold Limit Value (TLV) of 350 parts per million compares favourably with other commonly-used chlorinated solvents such as trichloroethylene (100 ppm). 1,1,1 — trichloroethane is, however, about twice as volatile as trichloroethylene and in cold degreasing this would offset the advantage of the higher TLV.

42 In 1980 the circumstances of a fatal accident involving 1,1,1 — trichloroethane were brought to the notice of the NIG. A young employee was found slumped with his head and upper body inside a small galvanised tank containing code 1,1,1 — trichloroethane. The tank was approximately 0.9m long x 0.6m wide and 0.6m deep and the top of the tank was about 0.75m from the floor. It was situated close to a large open doorway and the general ventilation in the room was good. There was 130mm of liquid in the bottom of the tank. Subsequently tests were carried out during the firm's normal degreasing operations. The procedure followed was to place one or two trays containing components on top of the tank. Using a 2½ litre can, liquid scooped from inside the tank was poured over the components and drained back into the tank via the perforated bottoms of the trays. Sampling showed that during this process the concentration measured in the breathing zone of the operator was 163 parts per million and the background samples in the department were all below the current TLV of 350 parts per million. The concentration measured 75mm below the rim of the tanks, however, was 73000 parts per million (7.3%) and 150mm below the rim of the tank 94000 parts per million (9.4%). The practice of pouring liquid trichloroethane over the components had the effect of drawing the extremely high

concentrations of the vapour much closer to the breathing zone of the operator and certainly to a position where it was foreseeable for the operator to be at serious risk of being overcome.

43 The details of this investigation, and of eight other similar fatal accidents, were circulated to all Engineering Groups of HMFI. It seems evident that the precautions required to ensure safe working at cold degreasing tanks are not fully appreciated in industry. Whichever chlorinated cold cleaning solvents are used the following considerations should be taken into account:

(a) the relatively high volatility of 1,1,1 — trichloroethane can allow dangerous concentrations of vapour to form easily even when it is used cold, and very high vapour concentrations (above 1%) can develop in and around tanks and containers;
(b) chlorinated solvents are effective anaesthetic agents if their vapours are inhaled in high concentrations, and if working methods permit an exposure to high vapour concentrations there will be a risk of an operator collapsing over or into the solvent containing vessel;
(c) high vapour concentrations are most likely to occur in open container operations where the system of work involves disturbance of the vapour layer above the solvent liquid level (e.g. by manually dipping components or by scooping the liquid in a small container), or by spraying or wiping operations in a confined space or poorly ventilated area;
(d) the dimensions or siting of the degreasing tank should be such as to reduce the risk of persons collapsing over, or falling into, the vessel;
(e) suitable mechanical handling methods should be provided wherever practicable so as to reduce the likelihood that persons will be exposed to high concentrations of solvent vapour; and
(f) where it is reasonably practicable lip exhaust systems should be fitted to control 'drag out' wherever there is mechanical removal of components.

44 When these factors are considered in a practical situation it should be borne in mind:

(a) that cold degreasing solvents are sold under a wide range of trade names and the purchaser or user should satisfy himself that the information made available by the supplier in accordance with his duties under Section 6 of the Health and Safety at Work etc Act 1974 is such as will allow the purchaser or user to make the necessary judgements about precautions;
(b) that the use of orinasal charcoal cartridge respirators is not considered an acceptable safeguard where high concentrations of chlorinated hydrocarbon vapours are present, and
(c) that the provision of local exhaust ventilation by means of booths or canopies should be considered critically in case they should impede the handling of components and thus encourage operators to lean over, or reach into, the degreasing tank.

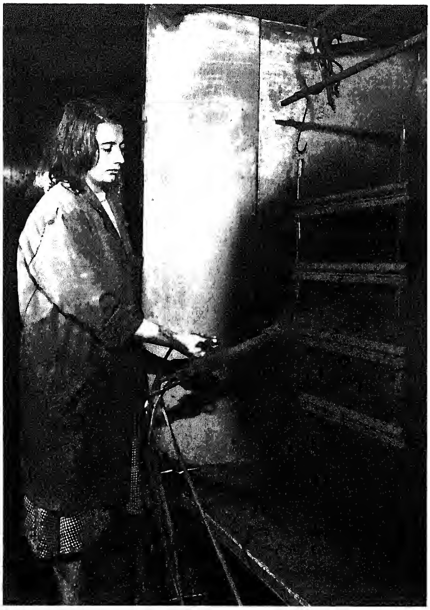

Fig 8 Manual powder spraying at open fronted booth

Electrostatic powder coating of metal articles

45 Electrostatically charged dry plastic powder can be made to cling to the surface of earthed metal articles in a thin layer and, when subsequently heated, form a protective film. The process is an attractive alternative to wet painting as it avoids the risks associated with flammable paint solvents and as well as being generally less expensive can provide a better surface finish.

46 The process involves the conveyance of the powder from a feed hopper to a spraygun where it is electrostatically charged and sprayed in the direction of an earthed metal article (Fig 8). Overspray powder is collected for reuse and the coated article is passed through a heated tunnel.

47 Hazards arise from the high voltage associated with the spraygun equipment and from the potential risk of flash fire or explosion if the concentration is allowed to rise.

48 The NIG has consulted with the Paintmakers Association of Great Britain on the revision of its Code of Safe practice in Electrostatic Powder Spraying which was first published in 1974 and which is due to be published in its revised form taking into account current British and European standards.

49 As a realistic standard of good practice the following precautions should be taken:

Powder handling

Where the powder is being handled or used, smoking and the use of naked lights should be prohibited in the area and care should be taken to minimise dust cloud formation and accumulation of dust deposits.

Spray guns

Manual spray guns should be capable of meeting the requirements of BASEEFA Standard 3010 Part 1 1974. For automatic guns the use of special electronic devices is to be encouraged which prevents the approach of a live gun to a work-piece or vice versa.

Operators

Spray guns should only be operated by persons fully conversant with the electrical and flammable risks of the process. The operators should not wear insulating shoes or gloves and the floor in the spray area should not be insulated. As far as practicable the operator should not enter the spray enclosure whilst spraying is being carried out.

Powder control

Exhaust ventilation should be applied to the booth to remove powder from the operators' breathing zone so that the concentration of powder in the air is below the relevant threshold limit value. The ventilation should also keep the overall powder concentration below its lower explosible limit or below 10 gm/m^3 whichever is the less. Deposits of overspray powder should be removed frequently by vacuum cleaning.

Earthing

All electrically conducting material inside the spray enclosure should be effectively earthed. Plastic sheet used in construction of the enclosure should either be anti-static and earthed or sufficiently thick to prevent an incendive spark discharge if excessive charging occurs. The earthing of articles to be sprayed should be monitored with an automatic earth monitor and the design of suspension arrangements such that paint or powder does not build up and interfere with the electrical contact between suspension and article.

Electrical apparatus

All electrical apparatus should be installed outside the spray enclosure apart from the spray gun itself. Any electrical apparatus which may become exposed to powder should be located so that it is not subject to uncontrolled dust deposition and should be provided with a suitable enclosure (standard flameproof apparatus is NOT suitable for this purpose).

Dust collection system

Generally dust collection systems with a capacity of greater than 0.14m^3 should always be sited outdoors in a safe place. If it is necessary to site them inside a building they should be contained in an enclosure capable of withstanding an internal pressure of at least 7 kN/m^2. All such enclosed collectors should be provided with explosion relief venting at not more than 3.44 kN/m^2 above the normal working pressure and discharging to the open air through a straight duct. The area of explosion relief should be 1m^2 for every 4.5m^3 of volume for structures withstanding pressures of 7-14 kN/m^2.

Powder to be returned continuously from the collectors to the spraying process should be discharged through an explosion choke such as a rotary valve. Powder to be returned in batches should be kept in small strong containers strongly connected to the collector.

Breaking of cast-iron scrap

50 A commom way of breaking cast iron scrap into pieces of usuable size (e.g. for reprocessing) is by dropping a heavy weight on it. This is usually done by using a heavy ball suspended on the hoist rope of a suitable crane so that it can be dropped on to a pile of scrap with a reasonable degree of accuracy. When the ball is dropped there is a tendency for pieces of scrap iron to be thrown out, sometimes for considerable distances, to the danger both of employed persons and of property and persons in the vicinity of the scrapyard.

51 It is customary for workpeople in the vicinity (e.g. the crane driver) to be protected from this hazard but cases have been reported where jagged pieces of iron have been thrown considerable distances and damaged adjacent properties and caused alarm to residents. No injuries from this case have been reported to the NIG but complaints about near-misses have been received and action has been taken, in some cases by the issue of Improvement and Prohibition Notices, to ensure that adequate precautions are adopted.

52 The structure illustrated in Fig 9 was developed by one firm to overcome these hazards when balling is carried on at ground level. The illustrated building is constructed of a steel girder frame which is clad with sheet metal to provide an enclosure 20 ft square and 30 ft high. The metal cladding is of 0.5 in steel sheets to a height of 12 ft and zinc sheets above that. The crane driver is able to see the scrap cast iron through a mesh

panel at the base of the back of the enclosure and this, together with the provision of a fixed fly jib allows for accurate positioning of the ball. The material is fed into, and removed from, the enclosure through a pair of heavy steel doors which are kept closed during the balling operation.

53 The provision of a structure of this sort may not always be a viable proposition. Other considerations apart from these may be difficulties about obtaining planning permission in some of the built-up areas in which scrapyards are commonly found. Without effective protection, however, ground level balling is likely to be hazardous and perimeter fences as high as 30 feet have failed, in the experience of the NIG, to prevent fragments of scrap from being projected on to neighbouring properties with the consequent risk that persons may be injured.

54 One alternative method of overcoming the risk is to carry out the balling below ground level. Experience suggests that an effective containment pit would need to be something in the order of 12 ft deep, and even then it might be necessary (depending upon the type of scrap being broken) to provide additional shielding above surface. Such a pit would, of course, need to be properly lined and provided with substantial edge protection to prevent persons falling in. Thick timber members such as old railway sleepers have been found to provide suitable liners in some cases.

55 Explosives are sometimes used to break scrap iron. This is a highly specialised procedure and before the possibility of using it is considered it would be advisable to seek the advice of the Health and Safety Executive. The normal approach for advice will be to the local Principal Inspector of Factories.

General issues

56 In addition to those issues which are specific to the Engineering Industry (however widely defined), the NIG has also been actively involved in some subjects which have relevance over the whole field of safety and health at work. The principal examples of this are the use of electro-sensitive safety devices for the safeguarding of machinery and the safety implications of the use of progammable electronic systems for the control of machinery and plant.

Electro-sensitive safety devices

57 The Engineering NIG's interest in the use and development of electro-sensitive safety devices springs principally from their use as a method of safeguarding press brakes. The Joint Standing Committee on Safety in the Use of Power Presses had, prior to the formation of the NIG been responsible for the preparation of one of the standards* then available for the application of these devices in the engineering industry.

58 The most common electro-sensitive safety device in general use for the safeguarding of machinery in industry is the photo-electric device which detects an interruption in a beam of light and triggers the required response (e.g. stops the machine).

59 In the practical application of such devices a great many factors have to be considered to ensure their reliability. There are many industrial situations in which orthodox fixed or interlocked guards will continue to be the preferred solution to a machinery safety problem. Nevertheless there are circumstances where an electro-sensitive safeguard has the balance of advantage and in the present climate of technological

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* *Electro-Sensitive Safety Devices for Friction Clutch Press Brakes*, Eighth Report of the Joint Standing Committee of Safety in the Use of Power Presses — HMSO 1970

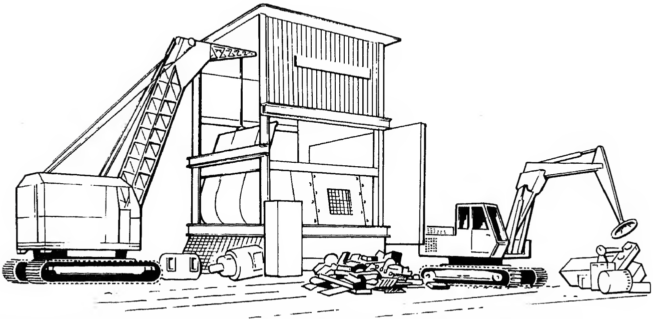

Fig 9 Breaking of cast iron scrap — safeguard for balling

change it may be expected that the use of these devices will increase.

Currently the application of electro-sensitive devices to friction clutch power presses is under careful consideration by the NIG.

60 If an electro-sensitive safety device is to be used in a machine-safety system the following are among the factors which will need to be considered. The system must:

(a) be protected against interference from external sources (e.g. stray light if it uses a photo-electric device);

(b) use a safety device which is reliable in operation and is capable of checking its own integrity;

(c) be capable of monitoring the function of interface components (e.g. valves, relays etc) between the safety device and the functions it serves to control; and

(d) be positioned such that there is no foreseeability of any persons reaching the danger area before the machine has stopped.

61 The JSC standard for friction clutch press brakes requires that if a vertical photo-electric curtain can detect a template of 1.5 in and is at a distance of 18 in from the nearest trapping point then the maximum time within which dangerous movement of the machine must cease after the insertion of the template is 200 ms. It cannot, however, be taken to be applicable as a standard to other systems or other types of machinery. The need for standards both for the safety devices themselves and for their application in specific safety systems is recognised and the NIG is co-operating with other branches of HMFI and with RLSD in seeking to establish them.

62 The Engineering NIG is represented on a Clearing Committee which has the function of reviewing, and commenting upon, new applications of electro-sensitive safety devices in the safeguarding of machinery. Its purpose is not merely to advise Inspectors about individual applications but also to assist the relevant National Industry Group in preparing standards for specific types of classes of machinery.

Programmable electronic systems for the control of machinery and plant

63 The use of numerically controlled (NC) or computer numerically controlled (CNC) machine tools has been common in the engineering industry for some years. The availability of cheap and efficient microcomputers has, however, brought about a tremendous increase in the use of programmable control systems for a wide range of industrial plant and machinery. In recognition of the importance of these developments and their possible implications for industrial health and safety a Technical Committee charged with the duty of investigating these developments, and of identifying problems arising from their use in manufacturing industries was set up in 1979. At the same time a Policy Committee was created with the object of providing an overview of the impact of these technological advances over the whole field of its concern including the likely effects on health and safety legislation. The Engineering NIG is represented on both these committees.

64 On the basis of the discussions of the HMFI Microprocessor Technical Committee, the NIG was able to prepare general advice on the safety implications of the uses of programmable electronic systems in factories and this was published in March 1981*. The paper is concerned with those factors which relate to all such systems and it is intended that advice on specific uses will be produced in due course. An appreciation of the general problem is, however, vital if such systems are to be used safely. In particular a person specifying such a system should, on the basis of his knowledge of the process, specify not only what must happen but also what should *not* be allowed to happen. The NIG has received reports of incidents arising from the use of programmable electronic systems and many of them might have been prevented by a proper appreciation of the potentialities of the system.

65 The use of industrial robots is one aspect of the new technology which has been of particular concern to the NIG in view of their growing use in industry particularly in motor vehicle manufacture (Figs 10 and 11). Unpredictable action patterns, the ability to move in free space and the possibility of reconfiguration all distinguish an industrial robot from other automated plant. Potential hazards include impact trapping and ejection of components and these hazards may arise not only during the normal operation of the machine but could occur as a result of a control malfunction or program error. Although many robots are used in dedicated applications, their ability to adapt to batch changes will be increasingly exploited and there will often be a suite of programs to cover a range of tasks. Accurate documentation to distinguish between programs will then become important.

66 The Engineering NIG has recognised the potential safety benefits which new technology offers including the opportunity to relieve workpeople of dangerous and arduous tasks and to automate load/unload operations at machines with moving platens (e.g. presses, diecasting machines). These benefits however, may be accompanied by new hazards or result in placing different groups of workpeople at risk. A number of accidents involving robots have been reported in other countries and these show that a robot

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* HSE Occasional Paper Series OP2: *Microprocessors in Industry – safety implications of the uses of programmable electronic systems in factories.*

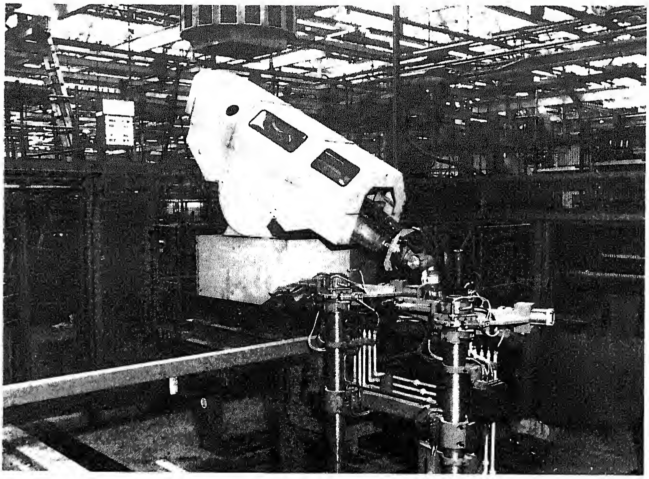

Fig 10 Robot used for spot welding in Motor Vehicle Manufacture (Close up view within interlocked enclosure)

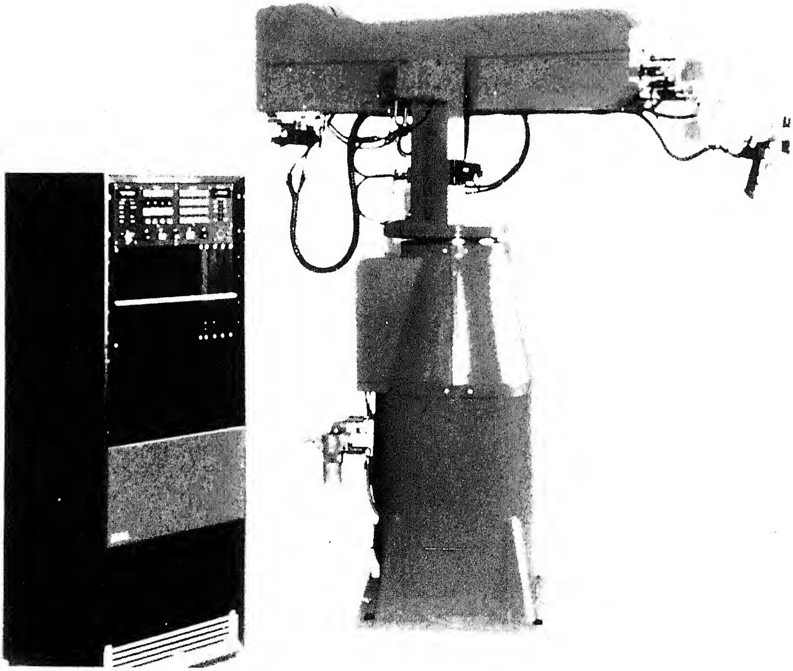

Fig 11 Programmable robot and control cabinet

is least likely to cause an accident when in production. The problems seem to occur during the programming and maintenance tasks. There is a diversity of robot types, and programming methods vary but the most popular method of programming (or teaching) a robot involves operating the machine under a pendant control at close range. The programmer drives the robot through the desired sequence and enters his positional data into the memory. The complete sequence is then replayed and where necessary edited. During the trial run-through the need for close observation of the robot is often claimed particularly for arc welding. The safety of the programmer is at these times dependent upon the integrity of the robot controls and the programmer's recollection of the sequence of movements. Some manufacturers of robots provide a facility for reducing the speed/torque during the teach operation.

67 There has been a marked increase in the use of CNC machine tools as a result of the micro-electronics revolution. Numerical control of machines is not new but modern machines demand high standards of maintenance and Inspectors have reported collisions between work-pieces and tools caused by faulty programming or incorrect modifications. There have also been reports of unexplained movements of axes and these have been attributed to electrical disturbances. In at least three cases, the collisions have led to ejections of material causing personal injury. In one case pieces of a shattered drill bit resulted in loss of the sight of an eye. While modern machine tools do, in general, require less frequent access, this apparent 'new' risk of ejection is being investigated by the NIG. There is a clear need for safe procedures to be adopted for proving programs and for subsequent amendments. These procedures could involve the use of program checking aids (X - Y plotters) or involve step-by-step operation at the machine perhaps using a soft material or with one axis cancelled. The more sophisticated computer controls on some machines can now be used to program at the machine on the shop floor. The NIG would like to see a more uniform approach by manufacturers to the guarding standards appropriate to these machines.

68 There are some factors common to all uses of programmed systems which can usefully be established and the NIG has been engaged with specialists from HMFI headquarters and from RLSD in seeking to establish some of these common factors. There is a move towards placing the computer as an element of the safety circuit whereby safety is a function of the correct operation of the computer. This raises questions of the integrity of the programmed system and introduces a new dimension to theories of safety interlocking. The use of computers for safety purposes is not new in itself but has hitherto been accompanied by complex checking systems and/or redundancy.

69 The NIG has been in consultation with industry and with the Machine Tool Industry Research Association which has produced a Code of Basic Principles for the safe use of robots. Members of the NIG staff as well as specialists from HMFI HQ and Midlands Field Consultant Group serve on the various drafting committees.

70 HMFI has also been involved in international discussions on safety in the use of robots following an initiative by the Department of Industry. In order to assist in the formation of a UK view, the Engineering NIG has brought together representatives of the major parties in the UK which have an interest in robotics in forming the Robot Safety Liaison Group. This group allows an interchange of ideas on safety problems between all those interests specialising in this field — including researchers, manufacturers and users of robots as well as representatives of the Health and Safety Executive. In this way the legal, practical and technical issues can be considered.

Conclusion

71 This report has sought to give some indication of the range of problems with which the Engineering NIG is concerned and has perhaps done so at the expense of the more mundane, though not necessarily less important, problems. A good deal of work continues to be done in the field of orthodox machinery safeguarding and in the up-dating of existing guidance and standards. Planned future initiatives include for instance the preparation of guidance on hazards in the heat treatment of metals, in the use of cadmium-containing filler metals in brazing, on the fencing of metal-baling machines and in the safe use of rolling road brake testing equipment. Some of the less common hazards which it is proposed to investigate include lead hazards in the repair of motor vehicle radiators and the safeguarding of electric lamp and tube-making machines.

72 Approaches will continue to be made to the various sections of industry to encourage the setting up of Joint Working Groups. It is hoped thereby to extend over an even wider spectrum the voluntary participation which is proving successful in raising Health and Safety standards in the Engineering Industry. It is the continuing challenge of facing the practical problems, and of stimulating interest in finding solutions to such problems, which is an essential function of a NIG. The Engineering NIG is confident that this challenge can be met by the active pursuit of the type of policies outlined in this report.

Appendix Industrial Classification assigned to the Engineering National Industry Group

Minimum List Heading	*Brief Description of Industry (for full description see 'Standard Industrial Classifications' HMSO, ISBN 0 11 630063 9)*
311/2 (part)	Forging of Steel.
312 (part)	Manufacture of fittings for steel tubes.
331	Manufacture of agricultural machinery and implements (except tractors).
332	Manufacture of metal-cutting and metal-forming machine tools, welding and flame cutting equipment, and other physio-chemical process cutting and forming machines.
333	Manufacture of pumps, industrial valves, air and gas compressors, and fluid power equipment (e.g. pneumatic cylinders).
334	Manufacture of industrial internal combustion engines, and other prime movers.
335	Manufacture of textile machinery and (metal) accessories.
336	Manufacture of construction and earth-moving machinery.
337	Manufacture of mechanical handling equipment including conveyors, cranks, transporters, lifts, escalators, lifting and winding devices and fork-lift trucks.
338	Manufacture of office machinery.
339	Manufacture of other machinery, including mining machinery, printing and bookbinding machinery, refrigerating machinery, heating and ventilating plant, weighing machinery, portable power tools, food and drink processing machinery, packaging and bottling machinery and other machinery except electrical machinery.
341	Manufacture of industrial (including process) plant and steelwork, other than oil rig and off-shore pipe line construction.
342	Manufacture of ordnance and small arms, including swords, bayonets, etc not manufactured by general cutlery firms.
349	Manufacture of ball and roller bearings, precision chains, and other mechanical engineering not specified elsewhere.
351	Manufacture of photographic and document copying equipment.
352	Manufacture of watches, clock and other time-keeping equipment.
353	Manufacture of surgical, dental and veterinary instruments and appliances and spectacles etc other than plastic components.
354	Manufacture of optical instruments and other scientific and industrial instruments and systems.
361	Manufacture of machinery for generating, transmitting and distributing electric power; switchgear, and control gear, and other electrical machinery.
363	Manufacture of telegraph and telephone apparatus and equipment.
364	Manufacture of electronic valves and other radio and electronic components.
365	Manufacture of broadcast receiving and sound reproducing equipment made from metal.
366	Manufacture of electronic computers.
367	Manufacture of alarms, signalling equipment and other radio, radar and electronic capital goods.
368	Manufacture of domestic electrical appliances.
369/1, 4 and 5	Manufacture of electrical equipment for vehicles (other than batteries and accumulators) and electric lamps, light fittings, wiring accessories, etc (other than plastic or glass).
380	Manufacture of wheeled tractors.
381	Manufacture of motor vehicles.
382	Manufacture of motor and pedal cycles.
383	Manufacture and repair of aerospace equipment.
384	Manufacture and repair of locomotives and railway track equipment.
385	Manufacture of railway carriages and wagons.
390	Manufacture of engineers' small tools and gauges.
391	Manufacture of hand tools and implements.
393	Manufacture of bolts, nuts, screws and rivets etc, other than wire nails.
395	Manufacture of metal containers.
396	Manufacture of jewellery and precious metals.
399	Metal industries not elsewhere specified (other than metal manufacture).
494/2	Manufacture of perambulators, push chairs etc.
499	Miscellaneous manufacturing industries (working primarily in metal).
832/7*	Scrap dealers.
894	Motor repairers, distributors, garages and filling stations.

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*With effect from 1 November 1982 responsibility for this MLH was transferred to the Steel NIG.

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